Closing loops in Cloud City

Towards Zero-Waste in Aalborg

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Towards Zero-Waste in Aalborg

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Circular Economy, Organic Waste, Ecological Transition, Material Flow Analysis

Abstract

Problem/Idea

Waste Management in the EU has in the past decade been guided by the 2008 directive (2008/98/EC) – itself a revision of the 2006 Waste Framework Directive (2006/12/EC). Now, however, a new and more ambitious package, the Circular Economy Package, including revised legislative proposals on waste, has been adopted (EC, 2015). This shift (from Waste Management to Circular Economy) underlines both the problem and a possible solution: In 2013, total waste generation in the EU amounted to around 2.5 billion tons per year of which more than 60 percent were not reused or recycled; valorization of waste (as a resource or secondary raw material) would increase competitiveness, create a substantial number of new jobs, avoid a considerable amount of GHG emissions, and reduce EU dependency on material imports.

For Denmark, long considered a pioneer in waste management despite it also being the EU country producing the most waste (759 kg per person in 2014, 60 percent higher than the EU average of 475 kg per person), the circular economy package introduces new challenges and opportunities. A very high fraction of the municipal waste in Denmark is being incinerated (54 percent), thus linking the waste system very closely with the energy system through highly effective and widespread district heating networks. However, despite being an effective way of waste management, such high rates of incineration are inconsistent with more ambitious recycling targets at EU, national and local levels.

As is the case in most Danish cities, in Aalborg, the reliance on incineration as a waste management and energy producing strategy is high. Almost 23 percent (1467 TJ) of the energy used in the city's district heating system comes from Reno Nord - the central waste incineration plant. Currently, for household waste, metal, plastics, glass, paper and carboard

are source collected. The rest, namely the refuse waste, is sent for incineration. The organic fraction, one of the largest groups in municipal waste, is currently still disposed within the refuse material.

Approach & Principles

With the introduction of a new waste management plan, Denmark Without Waste (2012 to 2022), the city has begun its own transition – under the heading 'Aalborg without Waste: 2014-2025' – towards more re-use of discarded materials from households. One target to live up to is the national goal of 50% recycling. A goal that is not achievable without a strong focus on the organic fraction identifying solutions to on the one hand prevent for example food waste, and on the other valorize the waste created and prepare for recycling.

In Aalborg, the new waste management plan is closely connected to political ambitions and goals for the transition towards a more sustainable future, and other official strategies and actions, such as Smart City Aalborg, the Sustainability Strategy and the Climate Strategy. It is also obvious, however, that the traditional and socially accepted model of waste incineration will need to be challenged, and that new solutions must be co-designed and co-planned to close loops and promote zero-waste society. The principles of Circular Economy (especially as presented by Ellen MacArthur Foundation) inspires politically and administratively in Aalborg, and their model is thus point of departure for the understanding and discussions of the possible circularity and loop-closing.

Case & Data

To exemplify opportunities for embracing circular economy business models, we propose utilizing current district and project developments underway in the city, and in early planning and design phase integrate to the extent possible functions that support waste prevention and recycling. The project, Cloud City, currently under planning (and with expected first-dig mid-2017) has been selected for a potential first zero-organic waste site in Aalborg. The Cloud City project, named after the central art piece by Tomás Saraceno that is to be installed, is a brownfield development in Aalborg's city center. It will transform a non-working industrial area into a multi-functional urban center. The project includes functions such as art exhibition, housing, rooftop urban gardens, food markets, hotel, restaurants, a micro distillery, and a chocolate factory.

A project this size and with these specific activities creates an opportunity for innovative design that focuses on closing loops in the organic resource and waste stream. To achieve a zero-waste district, the material flows must be identified and calculated, and resource utilization/treatment solutions needed proposed. The outflows were intended to be analysed through a material flow analysis, with data collected in a local context. However,

due limited feedback from stakeholders, appropriated data collected through literature review were used instead.

Design & Perspectives

The organic waste output in Cloud City was estimated at 16.7 tons per month. Assuming a 25% reduction in food waste (due to food waste prevention strategies), the estimated amount of waste is 12.8 tons per month. The second phase of study (ending June 2017) is now underway aiming at identifying areas of opportunity and proposing ways to close organic waste loops. The second section is inspired by the concept of circular economy and value creation. The expected results include a proposal for organic waste treatment that contributes to the general ecological transition of the district (and if scaled, the city). Moreover, it is expected to create enough knowledge that promotes further research on the topic.

Introduction

Waste and the organic fraction

Among the various aspects of sustainability, waste, specifically reduction and management, stand as one of the many imperative topics to be addressed. According to Hoornweg et al. (Hoornweg, Bhada-Tata, & Kennedy, 2013) , "*waste is being generated faster than other environmental pollutants, including greenhouse gases*". The present waste generation rates are already causing relevant phenomenon such as the marine-debris "Great Pacific Garbage Patch" between Japan and the US west coast. However, if this is not worrying enough, it is calculated that global solid waste generation could triple in the following century if a "business as usual" system is maintained; going from 3.5 million tonnes per day in 2010, to 11 million tonnes per day in 2100 (Hoornweg et al., 2013). Under this context, it is possible to identify waste management as a "*critical matter of public health, environmental quality, quality of life, and economic development*" (The World Bank, 2013).

In a European context, waste management practices have been guided by the Waste Hierarchy and the EU Directives. The next figure shows the waste hierarchy (Figure 1) followed by the European Union.

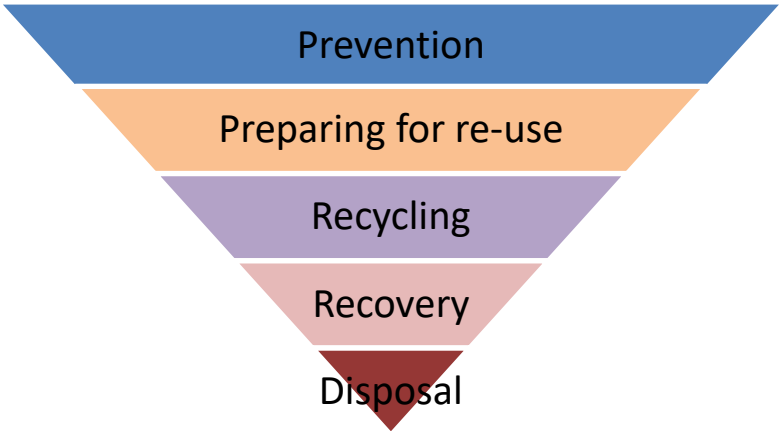

Figure 1- Waste Hierarchy

Within the EU directives, the most important highlights related to waste are: the EU Directive on Landfill (1999/31/EC), the EU waste Directive (2006/12/EU), the revised EU waste directive (2008/98/EC) and finally the Circular Economy Package adopted in 2015. The latter contains proposals "*on waste, with long-term targets to reduce landfilling and increase recycling and reuse*" (The European Union, 2017).

In cities, organic waste becomes a relevant fraction to consider for increasing recycling and reuse. Firstly, because on a global average, the organic fraction in municipal solid waste is 46% (Hoornweg & Bhada-Tata, 2012). Secondly, organic waste is linked to climate change due to methane emissions when decomposition takes place in landfills (European Commission, 2016). Thirdly, organic matter is concentrating in cities -due to urban area's high consumption- with nutrients not being returned to the soil. This is causing soil degradation on a global scale, affecting one quarter of land globally with a cost of USD 40 billion per year (Ellen MacArthur Foundation, 2017).

Denmark and Aalborg

Denmark is not only the country with more municipal waste generation in the EU (759 kg/person in 2014), it is also the second one regarding waste incineration (with 54%)(Eurostat, 2016). Moreover, the country falls behind Germany and Austria (countries with similar GDP per capita in 2015) (Eurostat, 2017) in terms of waste treatment. Germany performed better in recycling (47% against 27%), while Austria performed better in composting (32% against 17%). Under this context, and considering EU policy, it becomes attractive the analysis of a possible shift from an incineration dominated management to one focusing on prevention, reuse and recycling.

Given the circumstances, the Danish Government decided to take a new approach to waste management. On 2013, a new resource strategy "Denmark without Waste" was

implemented. With a motto "*Recycle more- incinerate less*", the Danish Government opted to promote a series of actions, focused on household waste recycling, to modify waste management in Denmark in a 10-year period -from 2013- to 2022-. A core goal of the strategy is to achieve a 50% recycling rate in household waste (up from 22% in 2011) (Government, 2013) for selected waste streams (organic waste, paper, cardboard, glass, wood, plastics and metals). However, the process will take place at different rates across the country. This is mainly because "*Municipalities are primarily responsible for the waste area, specially for household waste*"(Government, 2013). And different municipalities may decide to take different approaches into fulfilling targets and objectives. In this context, the Denmark Without Waste Strategy specifies: *"[…] the strategy contains no new requirements for individual municipalities. It will still be up to the individual municipality to set the level of service and organization of waste management*" (Government, 2013). Therefore, focusing in a specific location, or municipality, becomes relevant when analyzing waste management further.

Aalborg municipality is located in North Jutland and is Denmark's third largest municipality. The city of Aalborg is the largest city in the municipality but also it is North Jutland's capital. The city has actively participated in the European Conference on Sustainable Cities & Towns; events that have concluded in urban sustainability initiatives in the form of the Aalborg Charter in 1994, the Aalborg Commitments in 2014, and the Basque Declaration in 2016. In the latter, although many topics and scopes are mentioned, there is a strong connection with the concept of circular economy. This can be observed in some of the pathways statements stablished in the Declaration: "*We will turn the challenges in front of us into opportunities for our local economies*", "*We will create and close local value chains*", or "*We will pursue the development towards a Circular Economy*" (Declaration, 2016).

Approximately 129,000 tons of household waste were collected in Aalborg municipality in 2014 (Forsyning, 2014). This corresponds to 1,256 kg per household. According to the same report, the waste treatment for the same year was: 50.5% incineration, 44.4% recycling and 5.08% Landfill. Incineration is carried out by Reno Nord, in a local plant that burns waste from five different municipalities. From all the waste incinerated, the waste coming from Aalborg's municipality came primarily from the "refuse" category and from fuel waste (~72% and ~28% respectively)(Forsyning, 2014). The refuse category, which is entirely incinerated, refers to municipal waste that is left after separating things to recycle -such as paper, carton, plastics, metal, glass- and hazardous waste. Household organic waste is considered as non-recyclable, and therefore is separated within the refuse fraction along with items such as dipers, pizza boxes and multi-layered containers (chips, milk and juice cartons).

In this situation, it is possible to observe that the organic waste fraction is: 1) not collected separately, 2) it's collected inside the refuse category which normally contains non-recyclables, 3) it is incinerated entirely. Considering compliance with the national recycling targets for 2022 (of at least 50%), then it is possible to observe an area of opportunity regarding waste in Aalborg. The following graph (Figure 2) shows the incinerated refuse waste in Aalborg's plant (with data until 2015) and a linear forecast until the year 2022. A second line has been established to show the expected decrease in incinerated refuse waste if 50% of organic waste is being recycled by 2022 (considering that organic waste recycling nowadays is 0%).

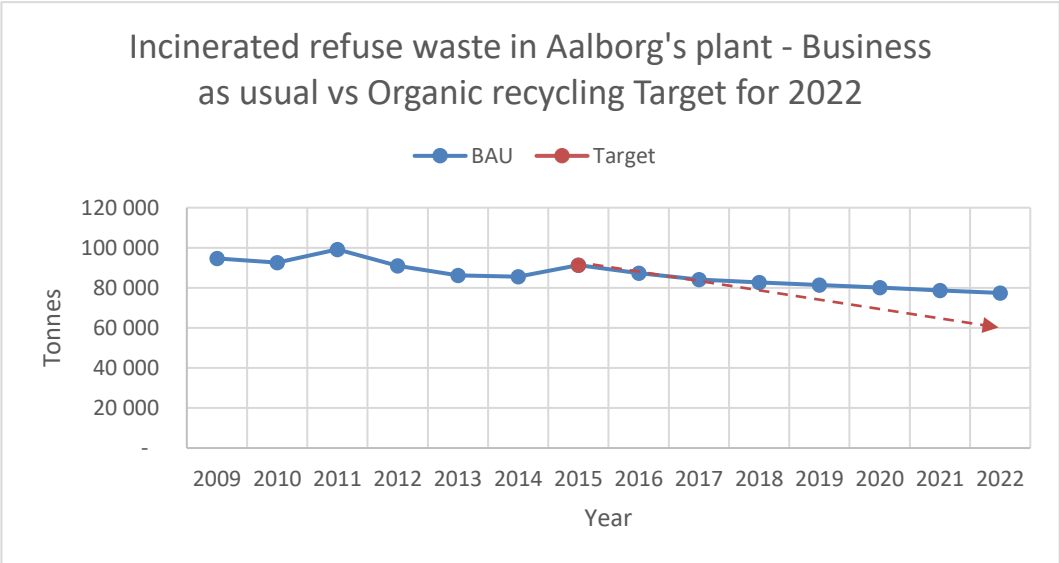

Figure 2- Incinerated refuse waste in Aalborg's plant - BAU vs Organic recycling target for 2022

The difference between the two scenarios that can be addressed through the design and implementation of innovative solutions. The solutions should be focused in the promotion of waste prevention, reuse and recycling -closing loops- above other options. Moreover, proposed solutions should not only need to be innovative, but should be able to break the present waste treatment trends on which the City, and the country, are at the moment. However, before designing potential solutions, a holistic understanding of the situation in Aalborg is needed.

The fact that organic waste is incinerated not only prevents waste recycling and reuse, but also links the waste sector with the energy one; particularly in the area of district heating. Reno Nord is one of the main contributors to Aalborg's District Heating system along with Aalborg Portland and Nordjylland Power Station (Nordjyllandsværket). According to Aalborg Varme (from Aalborg Forsyning), in 2014, the heat supply to the District Heating system was as following: Nordjylland Power Station with 56%, Reno Nord with 23%, Aalborg Portland with 18%, and 3% coming from the reserves (Aalborg Forsyning, 2017). In this

context, the importance of waste within the energy sector creates a circumstance where different interests, of different stakeholders, might compete. Moreover, this competition could slow down the ecological transition that the city is experiencing at the moment.

Therefore, the analytical framework will analyze Aalborg in terms of ecological modernization and institutional theory. Moreover, additional information will be given in terms of Circular Economy and Value Creation for organic waste.

Analytical Framework

Ecological Modernization

The sociological theory of Ecological Modernization will be used to provide a general framework on the current situation in Aalborg regarding its green transition. It should be highlighted that it is not the purpose to engage in a theoretical questioning or development approach; but simply into a descriptive task. According to Mol and Sonnenfeld (Mol & Sonnenfeld, 2000), Ecological Modernization appeared as an attempt to provide explanations regarding environmental transformations in practices, discourses and institutions. The theory was first developed in the beginnings of the 1980's, and has been, since then, under constant transformations due to multiple scientists contributing with various publications. Nevertheless the constant changes, at the core, "*the theory tries to analyze how contemporary industrialized societies deal with environmental crisis*"(Mol & Sonnenfeld, 2000).

In general terms, it can be argued that the approach in Aalborg is that of relating the "social" with the "natural". The very creation of the Center for Green transition (Center for Grøn Omstilling) in 2013, shows how the institutional context is constantly evolving due to environmental-induced changes. This approach is influenced by the EU policy, the Danish strategies and the city's commitments (Ex. Basque declaration), and is reflected in the specific approach of Aalborg's municipality. The municipality's Sustainability strategy is focused on "*consumption and resources and how SMART solutions based on circular economy can create green growth and social development in the municipality*"(Aalborg Kommune, 2017). In general, the strategy aims to benefit citizens, businesses and the environment at the same time. Moreover, other initiatives, such as the Green Agents (Grønne Agenter) -which support to citizen-driven initiatives- and the Green Stores (Grøn Butik) -an environmental labelling scheme-, relate the social and the natural within the already stablished institutions. Considering this context, it is possible to argue that the approach of the city is closer to a moderate position rather than a radical one. The municipality's sustainable initiatives support the idea of a need for reforms and transitions, but always within the current capitalist system. Furthermore, apparently, the sustainable strategy does not prioritize the environment above or below the social; rather they seem to

have the same importance. In the municipality's web information it states when referring to the sustainability strategy focus: "*it combines the desire for a sustainable transition with the citizens' well-being and quality of life*" (Aalborg Kommune, 2017).

In the context of waste, changes towards an ecological transition are evident. Regarding household waste, paper, cardboard and glass were already being separately collected by the municipality. And just recently, the streams of plastic and metal were added up to this list. This recent institutional change facilitates the possibility of increasing recycling and reducing incineration. However, when analyzing in greater detail, this is not the case for organic waste yet.

In general terms, although the city appears to be through a holistic process of ecological modernization (supported by EU policy, Danish policy and the municipality's strategies), there appears to be conflict that slows down the progression in terms of organic waste. Organic waste, along with other refuse material, is being incinerated. Considering that plastics and metals are currently being recycled in a higher percentage, a further reduction in waste going to incineration could represent a challenge in terms of energy supply. In this case, involved institutions could influence the path the city is going to take in the future. Moreover, political aspects influence the process as well. According to Dorte Ladefoged (Ladefoged, 2017), Waste Planner from Aalborg's Municipality, the city is planning on implementing biogas solutions in the close future. However, there are two reasons that prevented a separate collection of the organic fraction during the last years:

1. There is concern about the cleanness of the pulp (due to the presence of plastic material) produced in anaerobic digestion processes. The presence of plastic complicates the process of defining the "accepted values" for disposing pulp in the soil, along with defining where or to whom is the pulp going to be delivered. In this matter, currently there is no regulation in Denmark that stablishes limits. Thus, the decision is taken by the local government.

2. Joined to the previous point, future government changes also slow down the process. Elections are happening in 2017, and a new government bureau is expected for 2018. In this case, certain decisions, such as organic waste treatment, will be addressed until the new government comes (in order to avoid contradicting points of view between the past and new administration).

All things considered, a combination of circumstances is creating conflict among stakeholders that slows down the ecological modernization process in the waste setting. This conflict might be explained by the combination of both: the relationship of the waste and energy sectors, and the current political uncertainty (including future changes and the definition of limit values for pulp from anaerobic digestion processes). The previously

mentioned aspects involve the interaction of different institutions in Aalborg. These institutions might be competing to each other. Even more, certain institutions might be influenced by multiple factors the slow down the process of ecological modernization in terms of waste. Therefore, in order to describe and analyze this conflict, institutional theory will be used.

Institutions in Aalborg

In general terms, Institutional theory analyses the structures in society that shape and guide human behavior through systems such as laws, norms, common beliefs, etc. Such structures, which might seem static, can arise, transform and even disappear. Institutions are part of these structures.

According to Scott (Scott, 2001), the institutional characteristics are given by the "building blocks": regulative, normative and cultural-cognitive elements. The regulative, normative and cultural-cognitive elements conform what is known as the three pillars of Institutions. All of them are related to each other and sometimes they fall on a process of mutual reinforcing. Nevertheless, they are often separated since scholars, with different approaches, usually give a primary importance to a single pillar.

Even though all three elements might be seen as divergent conceptions (mainly to underlying assumptions, mechanisms and indicators (Scott, 2001)), in this present paper an integrated conception will be used. This means that all three elements are going to be considered equally relevant. Furthermore, the description will include different levels of analysis (from world system to organization sub-system). In this way, the current institutional situation of Aalborg will be explained.

The waste situation in Aalborg is characterized by conflict within different institutions that slow down the process of Ecological Modernization. Furthermore, the conflict is heightened by the relationship among the energy and waste sectors. This relationship among different institutions promotes a situation where behavior is guided differently depending on particular interests. Thus, having multiple conceptions of how society should develop slows down ecological progress. In this context, institutions in Aalborg will be identified within the three pillars.

On the regulative approach, actions are guided by coercive mechanisms through rules, laws and sanctions. Regarding waste in Aalborg, regulation can be seen all the way up to EU policy (specifically the EU directives), Denmark's Waste Strategies (Denmark without waste) and the local government in Aalborg. In the case of the EU directives, behavior is shaped by formal law; which in case of non-commitment could signify sanctions. In the case of Danish strategies, behavior is shaped by rules. And even if there are no proper sanctions to failing

targets, a case of non-commitment could be related to negative consequences. These two, EU and Danish regulation, are now focusing on the prioritization of waste prevention, reuse and recycling, and a general reduction on landfill and incineration. This stablishes clear objectives on the energy and waste sectors in Aalborg. However, conditions for the local government institution are not that clear. It should be considered that the waste targets are established on national level but the municipality is open to deal with the problem in their own way. In this context, according to Dorte Ladefoged (Ladefoged, 2017), in Aalborg, politicians represent the main stakeholder which decides what to do and how far to go. Coincidently, waste is now very popular in politics (Ladefoged, 2017). Thus, it is very likely that the local government implements rules and laws that fall in line with the approach taken by the regulation on EU and Danish levels. In this case, it would seem like the regulative institutions direct themselves into the same direction. However, the local government perception is influenced by other factors. This open the opportunity of decisions being made based on a normative or cultural-cognitive approach (something that might signify conflict when analyzed further).

On the normative approach, actions are guided by normative mechanisms through certifications/accreditation or pressure of social obligation. As an example, let's consider the European Union, but now through the Circular Economy Package. So far, the package is integrated by revised legislative proposals and an action plan. In this context, the proposals, as a whole, do not represent a formal rule or policy. Therefore, the European norms can be considered as something that is socially expected (through pressure of other environmental legit institutions) in a normative setting. In this context, the circular economy concept would promote a scenario with more recycling of waste. Nevertheless, in this pillar, other institutions might share, or not, the same point of view. As mentioned before, social obligation is relevant. However, such social obligation is created by several institutions which expect to guide actions based on different approaches. As an example of this, and considering the waste-energy connection in Aalborg, the European Sustainable Cities Platform would support a transition to more recycling, while Reno Nord might support the supply of services (district heating). In the same context, such differences on what is "socially obliged" would create conflict within the local government. Politicians, in this case people deciding what is going to happen, might take different points of view. This circumstance could slow down the ecological transition process within Aalborg. Additionally, in the normative approach, a moral aspect provides legitimacy. And morality is created within society through institutions. In this matter, the cultural-cognitive is intertwined with the normative approach.

On the cultural-cognitive approach, actions are guided through mimetic mechanisms through common beliefs and shared logics/understanding. What becomes culturally supported is what guides future processes. On one hand, In Aalborg, and Denmark in general, there is a strong historical incineration approach to waste. Even more, the

incineration processes are closely linked to the District heating systems which provide energy to households in a specific country with specific weather conditions. In such context, incineration can be seen as something that is taken for granted (therefore being mimicked) as the best (and maybe only) solution to the waste challenge. On the other hand, another part of the population could be aware of different methods to treat organic waste and could support their reproduction (treatment processes in other countries for example). In general, what is common belief depends almost in each person and in what they consider to be legit. This is the same case for politicians which could support different approaches to organic waste treatment.

A conflict between the three pillars of institutions is evident in Aalborg. Firstly, there is a regulative set of institutions pushing strategies that, in general terms, intend to reduce incineration. Secondly, another set of institutions, on a normative level, might legitimize actions towards circular economy but also to the supply of services -such as district heating- and the provision of jobs. In this context, it is morally accepted to incinerate waste in order to supply the city's energy demands. Thirdly, in the cultural-cognitive level, incineration could be -or not- supported by the population depending on the specific group of people. The historic use of incineration in the country could represent a solution that comes from a "common understanding". However, recent changes on regulative and normative levels, could modify these cultural-cognitive institutions into bodies that support prevention, reuse and recycling. Considering all pillars: a) the regulative might contradict the normative and the cultural-cognitive, b) the normative might have contradictions within what is morally accepted (what is socially obliged), but also might differ from the regulative and cultural cognitive, and c) the cultural-cognitive might have contradictions within what is understood as "normal behavior" and what should be mimicked; plus having differences with the normative and regulative levels.

All pillars of institutions are intertwined. Even more, differences arise within the same institutional levels (ex. variances inside cultural-cognitive). Thus, the differences, in what is considered legit, create a conflict that slows down the general sustainable transition of the city. In this context, it is necessary to initiate a new trend in a way that addresses the waste challenge considering these conflicts. Under the assumption that reducing incineration is the best option, waste treatment solutions should have as an objective to align the different institutional pillars. This means that actions towards incineration reduction should be socially accepted and validated. Support from people would provide proper legitimization, which in turn, would promote potential environment-induced changes in the present institutions in Aalborg.

Circular Economy and Value

Circular Economy is about leaving behind the linear economic model that has been around since the industrial revolution. The linear model is based on the assumption of unlimited inputs to production and consumption systems. However, recent pressure on resources, such as materials and energy, have led to the awareness that the number of available resources in the world is limited. In order to decouple resource scarcity from economic development, the obsolete linear model has to be substituted by a new approach. In this context, the concept of Circular Economy is highlighted. According to the Ellen MacArthur Foundation, Circular Economy "*is one that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times, distinguishing between technical and biological cycles*" (Ellen MacArthur Foundation, 2015). In more detail, to keep the "highest utility and value at all times", an economic model which includes recirculation (circles rather than lines) of products, components and materials is proposed (see Figure 3 for Circular Economy Figure).

Following the Circular Economy definition and principles, it is possible to link the circularity concept with Value Creation. If production systems are going to implement

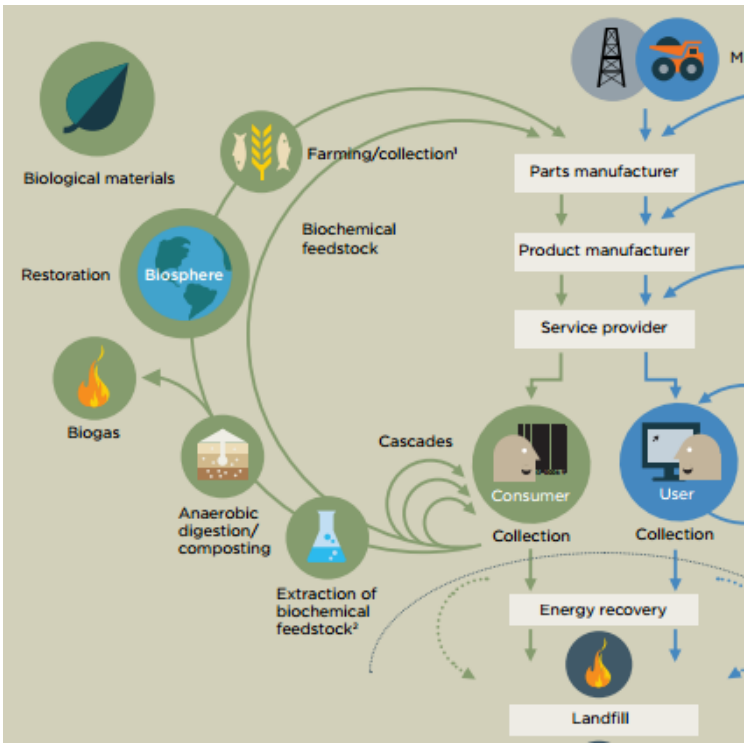

Figure 3- Circular Economy System - Biological Materials. Source: (Ellen MacArthur Foundation, 2014)

Circular Economy principles, then a restructuration of the supply chain needs to take place. It is in the new structure than value opportunities need to be identified and exploited. For example, one of the characteristics of Circular Economy is that "*waste does not exist, and is*

designed out by intention" (Ellen MacArthur Foundation, 2015). In this scenario, a company may be confronted with the need to creating value for spare materials.

The opportunities and mechanisms to implement the Circular Economy model in the biological cycles have been mostly unexplored (Ellen MacArthur Foundation, 2017). "*For biological materials, the essence of value creation lies in the opportunity to extract additional value from products and materials by cascading them through other applications*" (Ellen MacArthur Foundation, 2015). In this context, cascading refers to the potential to diversify reuse when compared to just landfilling. This becomes the only option since, in contrast with technical cycles, biological materials are "designed" to be consumed and then be used directly to regenerate the new raw materials. Nevertheless, it should be mentioned that this does not close the opportunity for waste prevention strategies. For the specific stream of organic municipal waste, the cascading to other applications could include: the production of concentrated NPK fertilizers (such as composting), energy recovery through anaerobic digestion, and the manufacture of products and materials traditionally derived from fossil fuels (ex. biorefineries) (Ellen MacArthur Foundation, 2017).

Considering the need to recycle organic waste in Aalborg, the present state of ecological modernization, the potential conflict among institutions and the multiple options to create value, it was decided to develop a proposal for a possible solution. In order to narrow down the scope of the research, it was decided to select a specific location for further analysis. This means that the present paper won't aim at changing the whole waste system in Aalborg, but will only aim at initiating a transition, through changes in a specific location, into a city with less incineration of organic waste. The location is defined by a new project that is under development called Cloud City. Cloud City is located in Aalborg's city center, and is integrated by a series of activities -within specific boundaries- that will generate municipal organic waste. Since the Cloud City project is currently under development, an area of opportunity is open to bring innovation.

Once the location and the problem were identified, the research statement and the research questions were established:

Closing loops in Cloud City: A zero-organic waste district in Aalborg.

a. *What are the expected solid organic waste flows in Cloud City?*

b. *How to treat the organic waste output and what value can it bring?*

Methodology

The present paper will develop a Case Study provided that the project happens in a real-life context, that it has defined boundaries -and therefore can be considered a defined unit of analysis-, and that the research will include a detailed analysis. In more detail, the present Case Study will take a problem-oriented approach -focusing on the "how to act"- rather than a cause/consequence analysis.

Case Study

Cloud City is a brownfield project currently under development -with expected first-dig mid 2017- in the western area of Aalborg's City center. The name is inspired by the central art piece, by Tomás Saraceno, that is going to be installed. In general terms, the Cloud City project will transform a non-working industrial area (previously a historical aquavit distillery that finished operations in 2014) into a multifunctional urban center.

The Cloud City project is expected to become an iconic center for art, innovation, smart solutions and sustainability, while preserving the historic identity of the city. The project aims at creating a vibrant space that brings life to the city by attracting residents (through housing), as well as local and foreign visitors. Furthermore, development will be divided into two: preservation of old industrial buildings and construction of new infrastructure. The following image (Figure 4), taken from the "Spritfabrikken I Aalborg" report (2016) from Bjarke Ingels Group, shows how Cloud City may look in the future. It shows the expected preserved old industrial buildings (red bricks) along with the new constructions.

Figure 4- Cloud City Project. Source: (Bjarke Ingels Group, 2016)

Cloud City is being developed by Martin Nielsen and by A. Engaard A/S. The project is expected to include functions such as: a theater, rooftop urban gardens, a food market, hotels, restaurants, a micro-destillery, art galleries, housing and a chocolate factory. Including everything, the total built area is approximately 75,000 m^2, and corresponds to a building percentage of 157% (Kommune, 2015). A report from Ramboll estimates, that in the first year, 1.6 million people will visit Cloud City (Ramboll, n.d.). Out of this number, it was estimated that 748,000 would correspond to "unique and paying visitors", of which 10% would be foreign.

By looking at the multiple activities within the area, it is possible to observe that many of the systems will be future sources of organic waste. This organic waste, which would fall on the classification of municipal waste, would mainly come from households, commercial/services, green areas/gardening and external sources (waste brought by visitors). In this context, the area could rely on the municipality for collecting the waste, or it could implement its own approach which may initiate a more radical change by breaking present trends in waste treatment.

Data Collection

In the present work, a combination of quantitative and qualitative methods is going to be used. The methods for data collection include literature review, interviews, surveys and mathematical calculations. Different methods and concepts will be used to answer the main research question and sub-questions. The following table (Table 1) will specify the methods and concepts used to answer the questions, and will give details on how data was collected.

Table 1- Methods and Concepts

Sub-questions	**Methods and Concepts**	**Details**
What are the expected solid organic waste flows in Cloud City?	Material Flow Analysis.	Data collected from literature review, surveys, interviews and mathematical calculations.
How to treat the organic waste output and what value can it bring?	Circular Economy, Value Creation	Data collected from literature review.

For the first sub-question, the first step was to identify the organic waste sources within Cloud City. Sources will be identified by analyzing data provided by the developers and maps of the site. Once the sources are identified, other data can be estimated. The research design for data gathering will carry out: a) personal contact with relevant services in Aalborg (such as chocolate factory, hotels and restaurants), and b) contact through phone and email to services not found in Aalborg but which are present in other parts of Denmark (such as food courts). Brief unstructured interviews will be used in local services, while surveys would be done for long distance communication. It is intended to obtain information in the most "local context" with the purpose of providing validity to the calculations. Literature review will be used to obtain the missing data.

Once the estimations for outputs are calculated, a proposal will be developed on how to treat the waste. This proposal is going to be described in the discussion section of the present paper and will answer the second sub-question. The proposal is going to be developed based on the concept of circular economy and value creation (briefly explained in the analytical framework) and will promote an ecological transition in synergy with the local institutions. Finally, the potential value will be identified in terms of the three bottom line aspects: social, environmental and economic.

Results

Waste Sources

To perform the flow analysis of organic waste in Cloud City, the first step was to identify the "processes" that could generate organic waste. To identify such processes, a specific procedure was carried out. First, a map of Cloud City was analyzed and buildings were identified. Then, each building was categorized in "Primary", "Secondary" or "housing". The classification was done based on the specific developers of each area and on the expected waste output. The buildings categorized as Primary and Secondary are being developed by Martin Nielsen. Primary refers to the buildings with the most expected waste output, while the secondary buildings are expected to have a small output. "Housing" is being developed by A. Engaard. All buildings in this category are houses, except for grocery store, and therefore it was decided to label them in a different category. The considered buildings were then analyzed further to identify the specific activities that are planned inside. Finally, the activities were analyzed to define the processes that could generate organic waste.

The following image (Figure 5)(based on the Spritfabrikken I Aalborg strategy report pg. 14) (Bjarke Ingels Group, 2016) shows the expected plans for Cloud City, and highlights the considered buildings of the project.

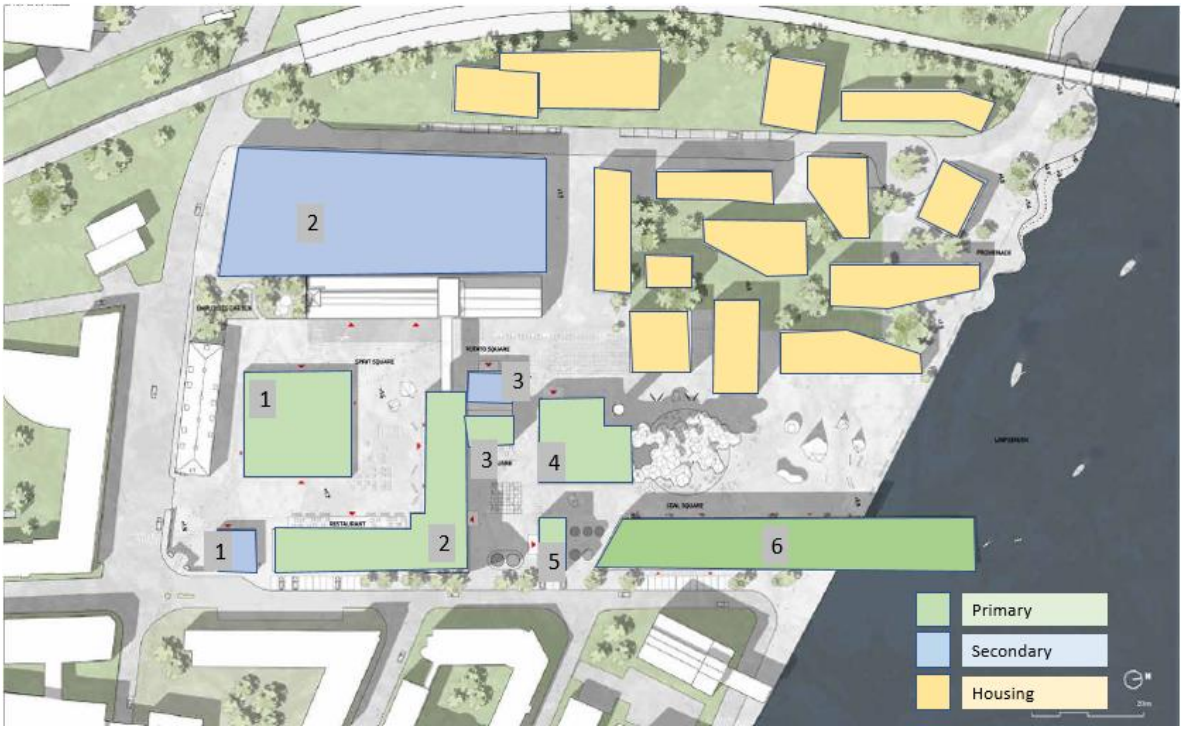

Figure 5- Cloud City considered areas

The following table (Table 2) specifies which buildings are considered.

Table 2- Considered buildings

Elements	**Buildings**
Primary	1) Market Hall (Torvehallen)
	2) Hotel
	3) Chocolate factory
	4) Art Hall + Coffee shop
	5) Micro-destillery
	6) Harbour Gate (Havneporten)
Secondary	1) Shop

	2) Theater
	3) Boutique Shop
Housing	1) Housing 2) Grocery Store

In more detail, each building is composed of at least one activity; and each activity of at least one process. The following table (Table 3) shows the primary buildings "processes" that were considered in the calculations. Most data was gathered from the "Spritfabrikken I Aalborg" strategy report from Bjarke Ingles Group (Bjarke Ingels Group, 2016) and by information provided by Martin Nielsen, developer of the Cloud City Project.

Table 3- Processes in Primary Buildings

Building	**Activities**	**Processes**
Market Hall	Restaurants	Kitchen, cutlery Clients (food disposal)
Hotel[1]	Hotel	Food consumption in Rooms
	Restaurants	Kitchen, Leftovers
	Apartments	Regular food consumption
Chocolate Factory	Chocolate factory	Chocolate production
Art Hall + Coffee	Cafeteria	Kitchen

Micro Destillery	Destillery	Alcohol production
Harbour Gate	Apartments	Regular food consumption
	Restaurants	Kitchen, leftovers
	Roof Garden	Garden Maintenance, garden output

Secondary elements are considered to have very small organic waste outputs. In this context, secondary elements are not going to be taken into account as organic waste sources.

The processes for housing elements are simply household. The following table (Table 4)provides more details about the specific characteristics in the housing buildings:

Table 4- Processes in the Housing Elements

Buildings	**Activities**	**Processes**
Housing	Apartments	Regular food consumption
Grocery Store	Retail store	Non-sold organic material

Waste Outputs

Once the organic waste sources were identified, the next step was to estimate the waste flows in the system. Initially, it was expected to use the concept of Material Flow Analysis to describe the organic waste "digestion" in Cloud City. However, due to time constrains and the specific needs of the present work, it was decided to focus on the Organic Material Outputs only (and not consider inputs or stock). Therefore, the study didn't carry out a

Material Flow Analysis, but considered only material outputs of each process within Cloud City. The decision was made since it was considered that having the output information would be enough to design a solution for organic waste recycling. In this case, having the output calculation would allow to calculate the size of needed infrastructure and potential energy production.

Gathering data from local sources, as expected from the research design (see Data collection section on page, was the main challenge. Contact in person was stablished with local hotels and chocolate shops. Contact by phone and email was stablished with a chocolate factory, hotels, a recycling company and food courts/food markets. No data was gathered from any of this sources since: a) they didn't have the information or b) No answer was given after several contact attempts. Therefore, the output calculation is completely based on literature review assumptions (see Annex in page for full list of assumed values) and assuming the project has been running for 5 years. The expected waste outputs for the different processes are summarized in the following table (Table 5):

Table 5 - Expected Organic Waste Outputs in Cloud City

Building	**Detail**	**Size**	**Organic waste output (kg/month)**
Market Hall	Food Market Booths	5 booths – 33.6 m^2 2 booths – 16.8 m^2	2191.52
Hotel	Rooms	-	No Data*
	Restaurant 1	200 seats	554.76
	Restaurant 2	150 seats	416.07
	Restaurant 3	140 seats	388.33
	Restaurant 4	140 seats	388.33
	Restaurant 5 / skybar	200 seats	554.76
	Apartments	6 apartments	21.6

Chocolate Factory	Production	330 m^2	5.22
Art hall / Coffee	Coffee Shop	-	9.16
Micro Destillery	Production	880 m^2	1,071.61
Harbour Gate	Apartments	13 apartments: 65-100 m^2	205.4
		19 apartments: 101-150 m^2	431.68
		1 apartment: 350 m^2	23.2
	Restaurant 1	150 seats	416.07
	Restaurant 2	75 seats	208.0375
	Terraces	-	No Data*
Green areas	-	-	Not included**
Bins	Bins within Cloud City	-	No Data*
Housing	Youth housing	120 apartments: 50 m^2	883.2
	Small Families	120 apartments: 65 m^2	1,516.8
	Family	100 apartments: 85 m^2	1,704
	Big Family	175 apartments: 100-150 m^2	3,248

Grocery Store	-	1,200 m^2	2,458.35
Total		(Kg/month)	16, 696.15
		(Tons/month)	16.7

* No data was not found in literature review or other sources. Moreover, it was considered to be negligible and therefore was not accounted for.

**Green areas waste is not considered in the calculation since this waste can be collected by the municipality and taken into compost. This is the normal procedure for garden waste in the municipal fraction in Aalborg.

The estimated total output of organic waste, in year 5, in Cloud City is: 16.7 tons per month. However, this number might change if we consider present, and future, strategies that target organic waste prevention. For example, considering the United Nations Sustainability Goals, there is an adopted target to reduce the per capita food waste, in retail and consumer level, by 50% by 2030 (European Commission, 2017). In this matter, European countries are committed in fulfilling this target. As a second example, Denmark, in an exemplary change within the European countries, has cut down food waste in 25% in the period between 2011-2016 (Senet, 2016). If we consider both facts, and assume the values in 2011 as the initial period when considering the UN targets, it could be assumed that the country would need to reduce an extra 25% of food waste by 2030.

According to the Cloud City's project developers, the area is going to be managed in a sustainable and responsible way. Assuming prevention strategies are going to be implemented, and considering the targets for 2030, it was decided to stablish a 25% reduction in the calculated organic waste output number for restaurants, apartments and the food market. Therefore, the total organic waste output in Cloud City would be 12.8 tons per month, or 153.6 tons per year.

Discussion

The calculated amounts of generated organic waste in Cloud City are approximations. This is expected since the information, regarding the place and its planned developments, was limited. Moreover, the information which was expected to be gathered in a local environment was not provided by the stakeholders. Therefore, as a last resource, the data was calculated assuming a variety of numerical assumptions based on literature review. Most of the information was gathered from Danish sources, however, there are some sources based in other geographical contexts. In this context, the accuracy, and therefore the validity, of the numbers becomes questionable. Nevertheless, the importance of having such assumptions resides in the possibility of estimating potential treatment options and their possible impact. Even more, this could serve as a starting point for planning waste

management details -such as waste collection-, or for estimating the whole impact of developing such a project in Aalborg. In this particular case, specific attention is given to waste treatment.

Following the concept of circular economy, and value creation through cascading, possible solutions for waste treatment in the area include: Anaerobic Digestion and Aerobic composting. Both solutions would provide a higher value -when discussed in terms of the waste hierarchy- if compared to the current trend of incineration. Considering this, it is intended to design the basis for a waste treatment solution based on Anaerobic Digestion (see Notes) that would benefit the ecological transition of the city, while possible setting common goals among institutions.

Notes

The waste output calculation would serve as a basis for designing a proposal for waste treatment in Cloud City. However, the proposal is not finished yet at the time this paper was submitted. The reason for this is that the present work is based on a Master Thesis paper that is begin developed by the author as part of his studies (from February to June 2017). Therefore, the second sub-question is not answered in the present work. However, it is intended to include this last section in the final Master Thesis paper. The last draft will include the proposal basis along with an identification of the total value a project like would bring to the City.

For further information it is recommended to contact the author through email.

Conclusion

Organic waste treatment through recycling solutions is the trend for Denmark for the future. This statement is supported by the regulation on EU level, the national level and by the municipal objectives. Even though the road towards less incineration seems clear, the process has been slow. In general, the ecological transition of Aalborg, in terms of waste, has been slowed down by different institutions -and their different pillars- including politicians and the waste/energy sectors. Therefore, waste treatment solutions should integrate institutional differences in their design, while creating the most value possible.

Providing a localized solution in Cloud City not only creates a zero-organic waste district in the city of Aalborg, but also builds the foundations towards a transitions towards less incineration. A project with this dimensions works as a knowledge creator that not only could benefits the city, but also the municipality and the country in the long term.

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1: A fitness/ well-being center not included since the organic waste flows are expected to be negligible